

EGU24-18389, updated on 22 Apr 2024

<https://doi.org/10.5194/egusphere-egu24-18389>

EGU General Assembly 2024

© Author(s) 2024. This work is distributed under the Creative Commons Attribution 4.0 License.



The role of earthworms in the organic matter cycling of forest floors in temperate forests – A mesocosm experiment with labeled beech litter

Philipp de Jong, Patrick Schleppei, and Frank Hagedorn

Eidg. Forschungsanstalt WSL, Biogeochemie, Birmensdorf, Switzerland (philipp.dejong@wsl.ch)

Earthworms may act as double-edged swords for soil organic matter (SOM). While they can enhance organic matter (OM) mineralization via increased microbial activity they can also elevate OM stabilization in aggregates as particulate or mineral-associated OM. In this study, we are testing this potentially opposing impact in beech-dominated (*Fagus sylvatica* L.) mixed forests on limestone, a forest ecosystem with particularly high earthworm activity. A specific focus lies on OM transformation along the continuum from the forest floor (O horizons) to mineral soil (A horizons). The forest floor can represent a substantial OM-pool which is an important source for SOM formation via bioturbation or leaching but can be vulnerable to alterations due to climate change. In a lab mesocosm experiment, we are incubating local earthworm species in soil columns consisting of O and A horizons from two contrasting beech forest sites from 600 and 1250 m elevation in the Swiss Jura Mountain range. Both sites have a mull-type forest floor with the high-elevation site exhibiting an Of horizon present throughout the year while an Of horizon is not present all year at the low-elevation site. We established four earthworm treatments for each site all including the respective mineral soil and forest floor: (1) no earthworms, (2) two *Octolasion cyaneum* S., (3) one *Lumbricus terrestris* L., and (4) two *O. cyaneum* together with one *L. terrestris*. In this setup, the Oi horizon was replaced with beech litter highly enriched with ^{13}C , ^{15}N , and ^2H . Soil respiration (CO_2) and leaching (C, N, and H in dissolved OM) are repeatedly measured. Total respiration (^{12}C and ^{13}C) is measured weekly for the first four months and biweekly afterward. Every two months fluxes from A and O horizons are measured separately. After approximately 4 and 10 months each, a set of mesocosms is harvested to investigate isotope enrichment in earthworm biomass, cast, physical soil fractions, PLFAs, and microbial necromass. We find first indications for stabilization of new litter input as, under similar total CO_2 fluxes, the litter-derived fraction is higher for treatments without worms. However, if both earthworm species are present, the cumulative heterotrophic respiration is elevated compared to the treatments involving only one earthworm species and the no-earthworm treatment. This is presumably due to higher earthworm density and, therefore, increased bioturbation. In contrast, we find no differences in the amount of dissolved organic matter leached out of the mesocosms between the treatments so far. X-ray CT scans will inform us about earthworm behavior within the mesocosms. This will help us understand how their activity translates into the vertical distribution of the isotopic label.

The role of earthworms in organic matter cycling in forest floors of temperate forests

Philipp de Jong^{1,2}, Patrick Schleppi¹, John Koestel³, Sebastian Doetterl² and Frank Hagedorn¹

¹Biogeochemistry, Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf, Switzerland; ²Soil Resources, Department of Environmental Systems Science, ETH Zurich, Zürich, Switzerland; ³Soil Quality and Soil Use, Agroscope, Zürich, Switzerland
Contact: philipp.dejong@wsl.ch

Earthworms and forest floors

As the direct **interface** between atmosphere and mineral soil, the forest floor can be **vulnerable** to alterations due to climate change or forest management. It can represent a crucial organic matter (OM) pool, which can serve as an important **source for soil OM formation** via bioturbation or leaching within forests.

While earthworms may **enhance OM mineralization** via increased microbial activity, they may simultaneously **elevate OM stabilization in aggregates** as particulate or mineral-associated OM.

In this study, we will test this potentially opposing impact of earthworms on OM dynamics in **beech** (*F. sylvatica* L.) forests **on limestone**.

Methods

- Soils, forest floor and earthworms sampled from two sites with different mull-type forest floors in the **Swiss Jura Mountains**
- Incubation of **beech litter (300 g m⁻²)** with combination of local species for one year (*Lumbricus terrestris* L., *Octolasion cyaneum* S.) at 16 °C
- **Respiration** measurements of ¹³CO₂ (weekly to bi-weekly)
- **Leaching** and subsequent dissolved OM (DOM) collection after artificial rain events every month (DO¹³C, DO¹⁵N, ²H₂O)
- **First harvest** of 1/3 of the mesocosms after four months, **final harvest** after approx. 12 months
- **Fractionation** of harvested forest floor and mineral soil into density fractions

Experimental setup

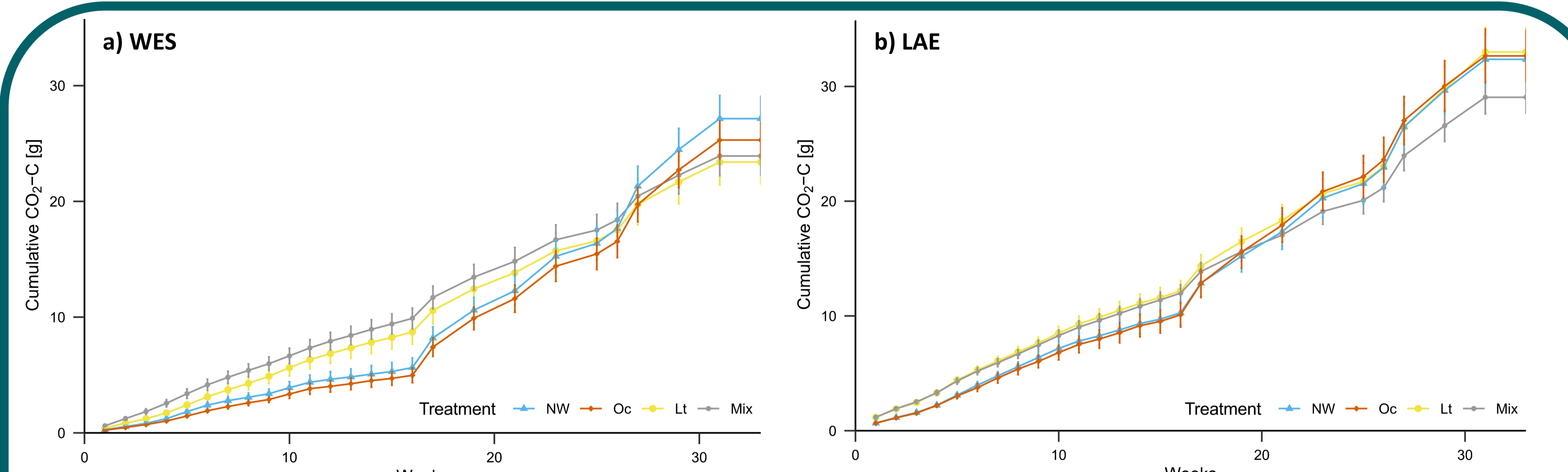
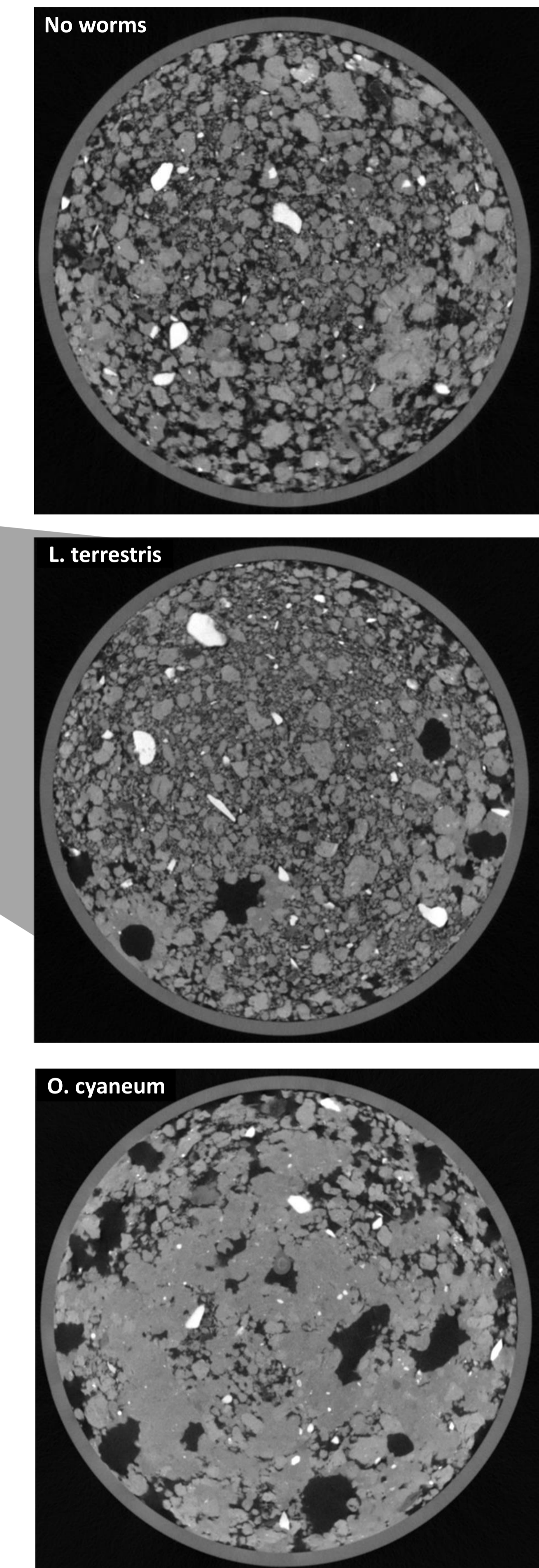
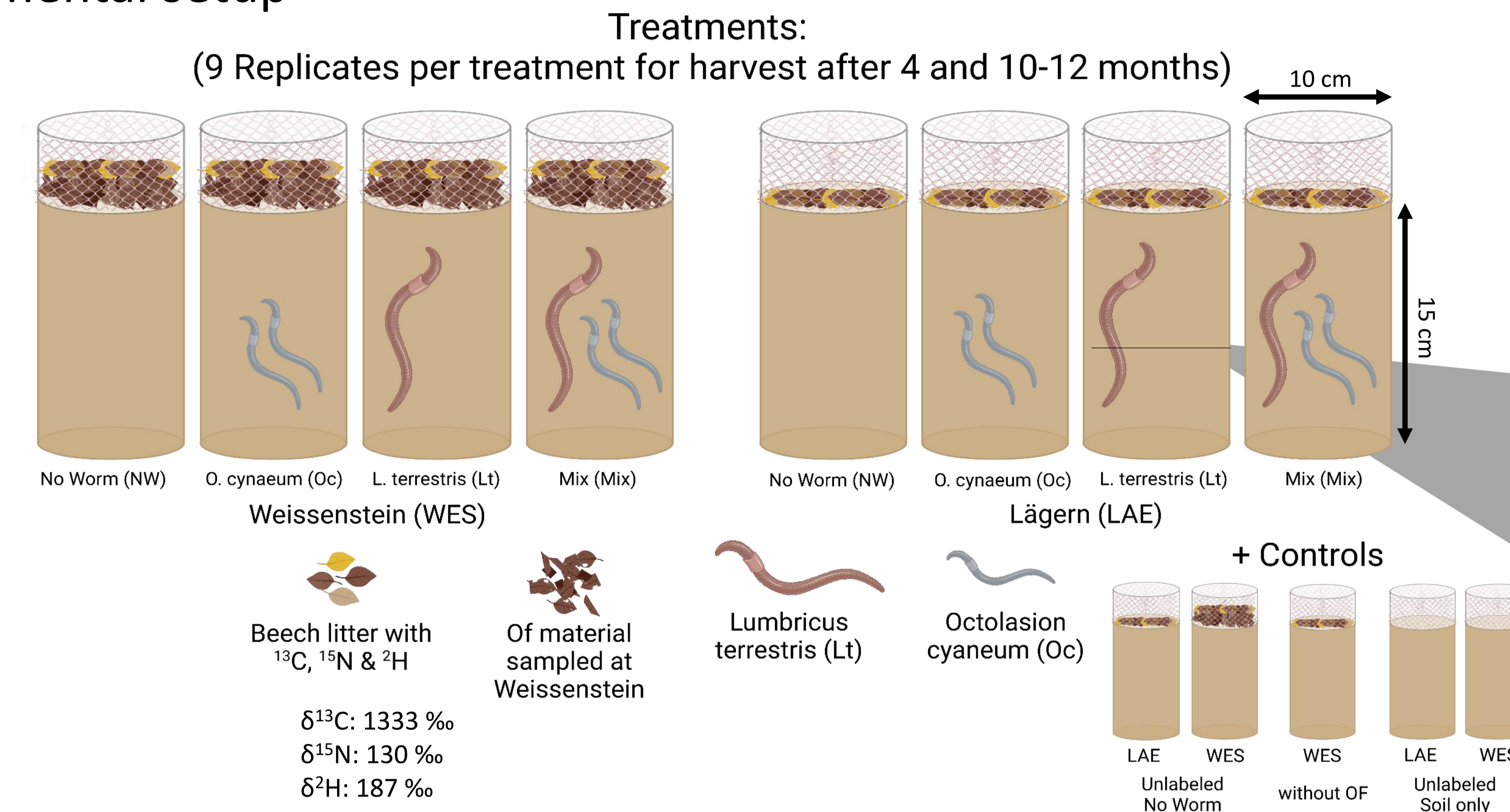


Fig. 1: Cumulative litter-derived heterotrophic respiration derived from a two-pool mixing model for the first 33 weeks of the experiment for the sites WES (a) and LAE (b). Values are mean values per week interpolated between two consecutive measurements. Error bars depict standard errors (n=6) cumulated over weeks applying the error propagation law for addition.

Fig. 2: Example horizontal slices from X-ray CT scans done on mesocosms before the first harvest after 4 months. All examples are approximately from the middle of the mineral soil column and from mesocosms of the site LAE.

Results:

- Litter-derived C loss via **heterotrophic respiration** in *O. cyaneum* or no-worm treatments **converged** (LAE) or **surpassed** (WES) the *L. terrestris* containing treatments (Fig. 1)
- Worm species alter the soil matrix differently: As expected *L. terrestris* **builds few permanent burrows** but *O. cyaneum* **mixes the mineral soil matrix** thoroughly (Fig. 2)

References and Credits:
- Figure 1.: Created with BioRender



Abstract

Forest Floor
FOR 5315

ETH zürich

